

COMMUNITY INFORMATION SESSION MINUTES

**The Former Memphis Depot
February 24, 2005
South Memphis Senior Citizen's Center
1620 Marjorie Drive
Memphis, TN**

The former Memphis Depot held a Community Information Session, which was held at 6:00 p.m. on February 24, 2005 at the South Memphis Senior Citizen's Center located at 1620 Marjorie Drive, Memphis, Tennessee. The attendance list is attached.

WELCOME AND INTRODUCTION

MR. DOBBS: Good evening. My name is Michael Dobbs. I serve as Program Manager for the Defense Distribution Center (DDC), and on behalf of the DDC and DLA (Defense Logistics Agency), I would like to welcome you to this evening's Community Information Session on zero-valent iron (ZVI). If you recall, some of the questions came to us at the last RAB meeting, and you requested some information, and that's what we're here to give you tonight.

I'm going to turn it over to EPA (Environmental Protection Agency). EPA is going to give you a little presentation. Following the presentation, there is to be some questions and answers, and then Tom Holmes from MACTEC will get up and give a presentation of the ZVI, and we'll open it up again for questions and comments.

PRESENTATION ON ZERO-VALENT IRON TECHNOLOGY

MR. DOBBS: So we've got that. Let me present Turpin Ballard and he will represent EPA.

MR. BALLARD: Good evening. I'm Turpin Ballard. I'm the Remedial Project Manager for EPA, Region IV assigned to the Depot. I know most of you have seen me before.

At last October's meeting there was a request to have an expert who could explain the technology uses of zero-valent iron come and give a presentation to the community, and I've arranged for Dr. Ralph Ludwig to come and give that presentation. Dr. Ludwig works for the EPA Office of Research and Development. It's an environmental research laboratory in Oklahoma.

His focus is on groundwater, and the focus of that lab is on groundwater research remediation. He has a Bachelor of Science and a Masters of Science and a Doctorate of – sorry-- Bachelor of Science in Biology, a Master of Science and Ph.D. in Environmental Engineering from McGill University in Canada. Prior to being with EPA, he worked at the Site Remediation Division of Environment Canada's wastewater technology center, and at the Department of Energy's National Engineering Laboratory.

He joined EPA in 1998, and since then, Dr. Ludwig has provided technical assistance at EPA regional offices and conducted field research on the application of the permeable reactive barrier (PRB) systems and treatment zones for passive treatment of groundwater contaminants. He's also served as a speaker and instructor for regional and national short courses on permeable reactive barrier technology. Dr. Ludwig.

DR. LUDWIG: Okay, as Turpin indicated. My name is Ralph Ludwig. I am with the U.S. EPA Office of Research and Development; specifically, I'm with the Robert S. Kerr Environmental Research Center in Ada, Oklahoma. We are EPA's center for research in the area of groundwater protection and remediation.

So we have a lot of familiarity with the ZVI technology. It's a technology that's been around for over ten years now and which has been shown to be very effective in treating a broad range of contaminants, including the contaminants that you have here at your site. I'm just going to give you a brief overview of the ZVI technology tonight, talk about what ZVI is and how it works.

These are things I'm going to be touching on: talking about what ZVI is, how it works, what contaminants are treatable with ZVI, how we design for use of ZVI, what groundwater chemistry changes occur in the presence of ZVI, what the current application status of ZVI systems is and some of the ZVI emplacement methods and advances.

So, we're going to start by talking about what zero-valent iron is. Zero-valent iron is a term for pure iron or steel. And it's steel in the form of filings or powder. And it's been shown that this pure iron or steel -- zero-valent iron is very effective in treating a range of contaminants, including chlorinated ethenes, chlorinated ethanes, and chlorinated methanes as well as dissolved metals.

And at your particular site here you have chlorinated ethenes -- you have ethenes, you have chlorinated ethenes and you have chlorinated ethanes.

The most common use of zero-valent iron to date has been in the form of iron filings, which -- there we are. (Indicating) Okay, but

what we are using today is in the form of iron filings, which you see right here. (Indicating)

More recently, the zero-valent iron is now being used in a powder form as well. And this next slide is a magnified view of one of these ZVI powdered particles. As you can see, it's not a perfectly round sphere. It's a very irregular particle with lots of porosity, and what this tells us is that it has a lot of surface area associated with it, which indicates it has a lot of reactivity associated with it.

So what's the reaction mechanism; how does ZVI work? It's basically corrosion of iron that drives the process. It's the equivalent of the rusting process. In rusting, we have iron. Iron -- pure iron or zero-valent iron is actually very unhappy in nature. It has too many electrons, and it's very eager to get rid of these electrons. So what you have in the rusting process is you have oxygen in the presence of moisture, which is yearning for electrons, comes into contact with the iron, which is eager to give up electrons. So you essentially have this marriage made in heaven where the iron is eager to give the electrons to the oxygen; the oxygen is eager to take them, and, so, you get the formation of rust.

So the same goes for these contaminants called chlorinated ethenes, chlorinated ethanes, chlorinated methanes which we have at your site. They are eager to gain more electrons. So when they come into contact with the iron, which is eager to give up electrons, it's a marriage made in heaven. They react, and in the process, these chlorinated hydrocarbons lose their chlorine atoms and are, in effect, detoxified. It's corrosion of iron that drives the reaction. The iron provides the electron source for the reduction,

that is, removal of chlorine atoms, dechlorination of the organics, and the more highly chlorinated compounds degrade faster than the less chlorinated compounds.

So for natural trichloroethene (TCE), which you have at your site, it has three chlorine atoms associated with it. It will degrade faster than vinyl chloride, which only has one chlorine atom associated with it.

Okay, I don't want to discourage you with this slide. I just want to say a couple of key things here. This is the degradation process of trichloroethene, which you have at your site, in the presence of zero-valent iron. This molecule right here is trichloroethene, and you'll note that there are three chlorine atoms on this particular molecule: one there, one there and one there (Indicating). It also has a carbon atom, another one there and a hydrogen atom. What's important here is in the presence of zero-valent iron, this compound starts to lose its chlorine atoms, and that's what we're trying to do. We're trying to get rid of these chlorine atoms.

We get it in a form where it's no longer toxic, and this trichloroethene can be broken down by two pathways. All right, this one right here or this one up along here (Indicating). We end up with this particular product right here (Indicating). And you see there is no longer any chlorine atoms associated with it. It turns out that 90 percent of the degradation goes through this pathway right here (Indicating), and the important thing is that through each step there are these two electrons that are supplied, and these are electrons that are continually supplied by the zero-valent iron. So, that's what the zero-valent iron is all about; supplying these

electrons that allow the TCE to degrade ultimately to this compound and then ultimately to carbon dioxide.

This is just another schematic showing what happens. You have trichloroethene at the site. That's what we just talked about. I indicated that greater than 90 percent goes directly to the non-chlorinated end products -- actually, let me just go back to this -- to the previous slide.

This pathway is the root that 90 percent of the TCE degrades by. These compounds that you see here are very temporary. Once it goes to this compound, it breaks down to this compound almost immediately and then to this compound almost immediately. So you basically don't see these compounds in the solution.

Anyway, going back to the other slide now, as I indicated, more than 90 percent then goes directly to the non-chlorinated end products through this lower pathway that I was talking about. Then some of it, less than 10 percent, goes this other root, to what we call cis-dichloroethene, and then to vinyl -- 2 percent of that goes to vinyl chloride, 98 percent go directly to the end product, and then of the vinyl chloride that's produced, 100 percent then goes to non-chlorinated end products. And, again, that's our goal, to get rid of those chlorine atoms so that we end up with these non-chlorinated end products.

And here, this is tetrachloroethene or perchloroethene. You also have that at your site. We see here 66 percent in the presence of ZVI goes to the non-chlorinated end products, 30 percent goes to cis-DCE, which then 98 percent goes to non-chlorinated end products, and then 2 percent to vinyl chloride and 100 percent then

goes to non-chlorinated end products. So, again, that's the overall objective with the ZVI, is to get rid of these chlorine atoms so that we end up with these non-chlorinated end products that are nontoxic.

This is just a list of the contaminants that are treatable by zero-valent iron, and you've got these methanes, you have this guy at your site, you have that guy at your site. These are what are called ethanes here. (Indicating) You have this guy at your site, and that one at your site. These are what are called ethenes, and you have this one at your site, tetrachloroethene, trichloroethene. You also have cis-1,2-dichloroethenes. So this is -- as you can see, the ZVI treats a broad range of contaminants.

Okay, now I need to talk a little bit about the design of zero-valent iron systems, how we design for use of ZVI. I have to talk about what's called contaminant half-life concept. The half-life of a contaminant is the time it takes for the concentration of the contaminant to reach one-half of its original concentration. So, for example, if the original concentration of TCE is 100 milligrams per liter and the concentration after two hours in the presence of ZVI is 50 milligrams per liter, then the half-life of TCE is two hours.

And we determine half-lives using a column treatability study setup such as you see here. What we do is we take a sample from the site, groundwater sample from the site; we pump it into a column that contains the zero-valent iron, ZVI. So we will know what the concentration of the contaminant is going into the column.

For example, if we're looking at the trichloroethene, TCE, we know that -- let's say we know the TCE going into the column is 100 milligrams per liter, and these are measuring points along the length of the column. Let's say at this point we drew a sample and we find that it's 50 milligrams per liter, in other words, it's half of what this concentration was going in, and we also know that the rate of groundwater flow through this column or at the time it takes for the groundwater to flow from here to here is two hours. On that basis, we can then determine -- we determine that the half-life of the TCE with this particular groundwater sample is two hours.

So this then just lists typical half-lives for various contaminants, many of which you have here at your site. You've got this one, this one, this one. I believe you might have some of that. (Indicating) You have carbon tetrachloride -- so this is tetrachloroethene, trichloroethene, cis-dichloroethene, vinyl chloride, carbon hydrochloride, a lot like chloromethane. You have these contaminants at your site, and these are the typical half-life ranges for these particular contaminants, and you can see that for tetrachloroethene and trichloroethene rates from .5-2.

When we get to cis-1,2-DCE and vinyl chloride ranges from 2 to 6 hours, and this, again, goes back to the fact that these contaminants -- or these compounds have more chlorine atoms; therefore, they degrade faster, and, therefore, have shorter half-lives. These degrade slower because they have fewer chlorine atoms associated with them, and, therefore, their half-lives are longer.

This is now some data specific to your site. Groundwater sample - - data from groundwater samples that were collected from two wells at your site, and this monitoring well #54 data and

monitoring well #77 data -- and I'm just going to quickly jump ahead to show you where those particular wells are. And Turpin if you want to jump in here to elaborate where those are?

MR. BALLARD: A lot of you have seen this. This area is the area to the west of Dunn Field between Dunn Field and the MLGW (Memphis Light, Gas & Water) substation, and that road across the top there where it says MW76 is Menager Avenue. So it's basically Kyle, Menager and Rozelle Avenue, and the railroad tracks crossing over to the MLGW substation.

MR. LUDWIG: So, basically, groundwater samples were collected from those two wells, and these column treatability tests were then conducted, and these are the half-life values that were determined from those column treatability tests.

And one thing of note here, you will see that there are certain contaminants that are in monitoring well #54 that are not present in monitoring well #77 and vice versa.

And if we look at some of this half-life data, we will notice that within the monitoring wells the groundwater samples right in the two monitoring wells there is some variation in half-lives. We see here monitoring well #54 for tetrachloroethene -- ethane. We have -- in monitoring well #54 groundwater we have a half-life of 1.5 hours, and monitoring well #77 we have a half-life of 1.3 hours.

And, so, basically, when we set up our -- depending on where one would want to put one of these ZVI treatment systems, if one wanted to put one in the area of monitoring well #54, one would look at this data here. If one wanted to put the treatment system in the area of monitoring well #77, one would look at -- use this particular data here as a half-life data.

Okay, so, continuing the half-life discussion now, let's say that our column tests show that TCE has a half-life of two hours for treatment with ZVI. Now let's also assume that groundwater velocity is one foot per day, which is approximately what it is at your site. What that then indicates is that groundwater is moving one inch each two hours. That, therefore, means that there's two hours of residence time per inch of -- if this is water moving through ZVI, you would have two hours of residence time per inch of ZVI, where residence time is defined as the time spent in contact with the ZVI. And, therefore, we would have one half-life for each inch of iron thickness. And we can take that then further and take an example here where we would require -- where 12 half-lives would require 12 inches of iron. So if we need to go through 12 half-lives of treatment, we would require 12 inches of iron.

And I'm going to go to this next slide which -- well, okay. So again, if you're a little confused as to what I just said. If I have one inch of travel -- one inch of travel time is equal to two hours, and one half-life is equal to two hours. If both of these equal two hours, then this must equal this (Indicating). So one inch of travel through the ZVI is equal to one half-life of treatment.

So let's go through an example here. Let's say we start with trichloroethene, which you have at your site at a concentration of 10,000 parts per billion. We have said that one half-life -- let's assume that one half-life is two hours and that groundwater flow is at one inch every two hours. To go one half-life, from 10,000 PPB, one half of this concentration would be 5,000 PPB. So to get one half-life of treatment that is, going from 10,000 down to 5,000

PPB we require two hours of residence time. Our groundwater would have to be in contact with the ZVI for two hours, and we, therefore, require a one inch thick ZVI or one inch ZVI thickness.

We can take that further. If we want to go another half-life, down to 2,500 PPB, which corresponds to two half-lives, we need four hours of residence time or two inches of ZVI thickness, and we can take it and keep on going.

For example, if we wanted to get our TCE down to 2.5 PPB, then we have to go through 12 half-lives of treatment, which means 24 hours of residence time, which under our assumptions would mean that we need 12 inches of ZVI thickness to achieve our treatment. Okay, so, the first ZVI applications were in the form of what we call permeable reactive barriers, and that is something that is going to be used at this site. Permeable reactive barrier is defined as a permeable zone consisting of a reactive treatment area oriented to intercept and remediate a contaminant plume, and it removes contaminants from the groundwater flow system by physical, chemical or biological means. And in the case of ZVI, we're removing it by chemical means. This is just a conceptualization of a permeable reactive barrier. We have a groundwater plume, a contaminant plume moving in a certain direction. We then put this permeable barrier in the path of the plume so that when the contaminants flow through this barrier, the contaminants are removed so that the groundwater that exits on the other side of the barrier is then free of the target contaminants.

And, so, these ZVI and PRB systems have been shown to be very effective in removing many chlorinated hydrocarbons, including the hydrocarbons that you have here at your site. They've been

shown to be effective over long time periods. The first full scale wall was installed in 1995. It's still operating. It's treating trichloroethene, which you have at your site, and it continues to effectively treat trichloroethene.

These ZVI and PRB systems have low operating and maintenance costs associated with them, and there are no adverse geochemical reactions associated with them.

And I have to just briefly discuss this slide because this sort of summarizes the groundwater chemistry changes that occur in the presence of ZVI. And what you see, this is groundwater here flowing this way (Indicating), and this is your zero-valent iron zone. So when groundwater enters the zero-valent iron zone, certain things happen, the same things that happen when iron rusts. Basically, you have this thing here called pH, which goes up -- pH is a measure of how acidic a sample is. So lemon juice has a low pH. If we were to dissolve Roloids or Tums in water, it would have a high pH. And, so, when groundwater enters this iron zone, we get an increase in pH. The groundwater becomes less acidic. We also have more electrons.

This Eh, this thing here, measures electron activity. We know that iron is eager to give up its electrons to these contaminants. So you get more electron activity, and so the more electron activity you have, the lower this Eh value is. You have more -- you have iron going into solution -- Fe stands for iron. So you get some iron going into the solution, dissolving in the water. Calcium here decreases. Also alkalinity, very similar to hardness, decreases, and we also get some compounds that precipitate out, that come out of a solution, and these are minerals that are found in nature. The

calcium carbonate, which seashells are made from, the iron carbonate and which iron oxene -- iron hydroxide and iron oxene hydroxides, these tend to precipitate out, but, again, these are minerals that are commonly found in nature.

Now, once we get outside this iron zone, our pH again goes down, our Eh again goes back up, our calcium concentrations go back up. And, so, by the time we get a certain distance downgradient, we are now back to the level -- or back to the conditions of the groundwater that we were before it ever entered this iron zone. The only difference is now that this groundwater is free of the contaminants that we're trying to get rid of.

The first field trial of the ZVI system was this one at the University of Waterloo, which is in Canada. This was in 1991. So this was a permeable reactive barrier, a test permeable reactive barrier that was installed, and it was installed to treat trichloroethene and tetrachloroethene, which you have here at your site.

And, basically, groundwater flows along here. (Indicating) This is the PRB system here, and these are the kinds of results that they saw. This is trichloroethene, and as you see, as soon as it enters this zero-valent iron wall right here, you get this dramatic drop in the trichloroethene concentration. This is tetrachloride, and, again, as soon as it enters the wall, you get a sharp drop in concentrations. (Indicating)

At the same time, you get an increase in concentration of chloride ions, and what this indicates then is that these compounds are losing their chlorine atoms, and you're getting a formation of chloride ions in the solution.

This slide (Indicating) just shows that when TCE and PCE are treated by zero-valent iron, you do get production of some byproducts, such as cis-dichloroethene, 1,1-dichloroethene and trans-dichloroethene, but these contaminants are also treated within the ZVI system. So as long as your ZVI system is thick enough, these contaminants will be treated as well.

This is the first commercial PRB installation, the first ZVI full scale ZVI system installation. (Indicating) This is in Sunnyvale, California. This was a wall that's 40 feet long, 20 feet deep and I believe 3 or 4 feet wide, and it was installed to treat trichloroethylene, and it continues to operate today and continues to remove trichloroethylene.

This is a full-scale installation at Elizabeth City, North Carolina. (Indicating) This was installed in 1996 and is treating trichloroethylene as well as chromium and continues to operate today and effectively treat those contaminants.

This is trichloroethylene in compliance wells at this Elizabeth City site, and this blue data here are concentrations of trichloroethylene on the upgradient side of the PRB; in other words, before the groundwater enters the zero-valent iron wall. (Indicating)

This data, the yellow and the pink data, are from wells that are on the other side of the ZVI and PRB system, and, as you can see, you get dramatic different treatment than from what's on the upgradient side, and you can get very significant treatment through that zero-valent iron system.

Okay, what's the current status of ZVI and PRB systems? Again, this is the way most ZVI has been used to date. As of 1999, there were 22 full-scale systems. Currently there are 83 full-scale systems worldwide. They are not all PRB systems.

This is the status in the United States. There are 91 field installations. Some of these are pilot installations, some are full scale. And this is the situation globally. There are 16 installations in Europe now and 8 in Japan.

And I just want to say some words now about emplacement advances. As I indicated initially, earlier ZVI was used primarily as a permeable reactive barrier. Primarily its shallow permeable reactive barriers, like by digging trenches. That was an easy way to get this stuff into the ground. Recently there have been advances, and ZVI can now be placed at depths of greater than a hundred feet. It can be placed across selected depth intervals, and the recent advances now allow ZVI emplacement where trenching and excavation would otherwise have been problematic.

One of these advances is vertical hydraulic fracturing, and that's a particular method that is going to be used at this particular site. This involves injecting iron suspended in a guar-based slurry. Guar is a sugar in the form of a gel, and the iron slurry is injected at high pressure and low velocity, and this creates fractures, which propagate along vertical orientation. The adjacent fractures coalesce to form a continuous wall, and the slurry then breaks down, leaving the permeable iron barrier behind.

This is just a schematic of how that works. (Indicating) These would be the injection wells. These are the fractures that are

formed, and you get the overlapping of these fractures then to form this continuous wall.

Just to show that it works -- this is from a site in New Jersey where they did some hydraulic fracturing, and they went in afterwards and dug things up to verify that they actually got these -- this continuous wall system. At this particular site they were putting in two walls, and, as you can see, they were successful in getting a wall system in place using this hydraulic fracturing process.
(Indicating)

Another method of trying to get the zero-valent iron into the subsurface is a high pressure, high velocity, and this is a type of system that is also being considered for use at your site, and this kind of high pressure, high velocity ZVI injection system where powder is injected into the subsurface can be used to treat groundwater hot spots and will result in contaminant of mass reduction in groundwater if it's effectively applied.

So, in summary, I just would like to say that ZVI is an effective treatment media for contaminants such as those found in groundwater at the Dunn Field site. Contaminants are permanently destroyed, and during reaction over time, the ZVI is gradually transformed or oxidized back to its original form in nature; that is, back to iron oxide. Iron normally does not exist in nature as pure iron, and, so, what happens then, during this process it's being oxidized -- it's being reverted back to the form that it actually exists in nature, and ZVI does not adversely impact groundwater.

So, I've just given you sort of a brief overview of what ZVI is and how it works. There are certainly a lot of other sources out there

of information for you, and this here is a list of some good information sources if you're looking for more information on zero-valent iron. (Indicating) And with that, I would be happy to answer any questions you might have.

MS. PETERS: What happens -- Johnny Mae Peters. What happens to all this iron you have inserted, all of them inches of iron, once it does its job? Does it affect the water in any form?

DR. LUDWIG: No, it's -- what's happening is it's rusting. So over time it's going to rust. You have oxygen in the groundwater. The oxygen will react with the iron, and you're going to form rust, form what are called iron oxides, and iron oxides are what you find -- it's a form of iron that you find in nature. When they go and mine for iron to make steel, that's what they mine, they mine iron oxides, and then they put it in a blast furnace, heat it up to a high temperature to extract the iron and get the pure iron. So what we're doing -- what's happening here now is we're just reversing the process. It's now being reoxidized. It's going back to the form that it's found in nature.

Now, that takes place over an extended period of time. It's not going to take place over, you know, a one or two-month period. I mean, it takes place over many years, but it's just a natural rusting process that occurs.

MR. BALLARD: But the iron stays in place.

DR. LUDWIG: The iron stays in place.

MR. BALLARD: You don't remove it from the ground.

DR. LUDWIG: Right.

MS. PETERS: You know why I asked you that? Because, you know, doctors will put people on iron, and I wondered if that's the same type iron.

DR. LUDWIG: The kind of iron that you're talking about would be an iron that if you put it into the water, it would dissolve. You know, you have --

sort of like putting salt in the water, and, so, this is a different form of iron. And, now, as it gets -- you know, the iron basically stays in place. It doesn't go anywhere. It's like sticking those iron filings that I showed you, sticking them in water and watching the rusting process take place over time.

MR. WILLIAMS: So, you were saying that we're not going to be using the walls that they were talking about in this area, where they're building walls in the water where they build the walls in the water that's traveling through there?

DR. LUDWIG: Yes.

MR. WILLIAMS: Okay, so ---

MR. BALLARD: There's going to be a presentation on how we're using zero-valent iron at this site right afterwards.

MR. WILLIAMS: Okay, I thought he just said the way we were going to do it is to inject it into the water. Is that what you just ---

DR. LUDWIG: The zero-valent iron, yes.

MR. WILLIAMS: Okay, so, you are just injecting this in the water. That means it's traveling along with the water. Am I right?

DR. LUDWIG: No, no.

MR. WILLIAMS: It's just going to sink to the bottom?

DR. LUDWIG: Well, during the injection process, yes, it's going to travel however far it's going to travel over -- how long is this injection process?

MR. BALLARD: Twenty-five feet around the injection.

DR. LUDWIG: You're injecting for how long?

MR. BALLARD: Fifteen to twenty minutes.

DR. LUDWIG: Fifteen to twenty minutes. So, for fifteen to twenty minutes while they're injecting, yes, this iron powder is traveling out to maybe twenty-five feet or so.

MR. WILLIAMS: So this water at any point won't be screened, you know, like going through a screen or something that will catch the iron that might travel in the process of you ---

DR. LUDWIG: Well, you're trying to get the iron out to about twenty -- I think the objective at this particular site is to get it out to thirty feet. So you're trying to inject this powdered iron out thirty feet. Now, once it gets out thirty feet, it stays put.

MR. WILLIAMS: As long as the flow of the water is going, the iron then won't ---

DR. LUDWIG: Right, because they're heavy particles. Even though it's powder form, they're heavy particles. They won't flow with the groundwater. Yes.

MS. BRADSHAW: You haven't said what it won't clean up.

DR. LUDWIG: What it won't clean up?

MS. BRADSHAW: What it will not clean up. My name is Doris Bradshaw.

DR. LUDWIG: Okay.

MS. BRADSHAW: For the record, what you're not saying is -- you have gave us a list of toluylene and other -- ethylene, trichloroethylene and all those other names that goes in that category. Those are solids; right?

DR. LUDWIG: Right.

MS. BRADSHAW: So, actually, the iron cleans up solids, don't it?

DR. LUDWIG: Right, right.

MS. BRADSHAW: Well, maybe -- I didn't hear you say anything about it cleaning up radiation in the water.

DR. LUDWIG: Radiation?

MS. BRADSHAW: Right.

DR. LUDWIG: I don't know what its impact is on radiation.

MS. BRADSHAW: Thank you. That's all. Because Turpin told me at the last meeting that it would break down radiation also, but -- wait. Iron only cleans up the solids in the water, and it doesn't clean it up, as we say, pristine, back to where it is. It's still poison. You're talking about the half-life.

DR. LUDWIG: Yes.

MS. BRADSHAW: And we know TCE does not have a threshold level.

DR. LUDWIG: Well, eventually that TCE will be completely broken down.

MS. BRADSHAW: It's broken down. It's not away.

DR. LUDWIG: What? Sorry.

MS. BRADSHAW: You did not clean it all the way.

DR. LUDWIG: Sure, if your ZVI thickness -- if it's thick enough, it will completely treat the TCE.

MS. BRADSHAW: So, what you're telling us is you can drill a well down there and start drinking this water?

MS. PETERS: He didn't say that, I hope.

DR. LUDWIG: I'm not going there.

MS. BRADSHAW: I wanted to make that point. Be clear what you're telling us. Because I've talked to another scientist.

DR. LUDWIG: Okay. I don't know enough about your site to answer your questions. All I'm telling you is if I had water that has TCE in it and some of these other contaminants I mentioned and you have enough ZVI there, it will clean those particular contaminants down to zero. It will do that. Now I don't know enough about your groundwater here at the site. You know what else you might have in your groundwater and what some of the other issues are. I can't answer that question for you.

MS. BRADSHAW: You mean that they didn't -- EPA didn't inform you before you came here about this site?

DR. LUDWIG: Well, I've talked to Turpin a little bit, but my understanding -- the reason for my being here, my understanding, was to talk about the science. Apparently the request was we need somebody to talk about the science of ZVI.

MS. BRADSHAW: But not of this site.

MR. BALLARD: The question was "How does ZVI work?" "Where has it been used?" And, you know, "What does it clean up?" "How does it do that?" That was our understanding of the question, and "We want a scientist, we wanted an expert to come and talk to us about it." It wasn't to make him ---

MS. BRADSHAW: See, Turpin, I hate this, the question things. Because you know what, you get what you ask for, but you don't get all of what you asked for. Because we needed an intelligent discussion on this particular site, but I want to put in the minutes that when I was out in California, I did get an opportunity to talk to another scientist, because you said something about Hunter's Point. I have colleagues at Hunter's Point. I have colleagues all in California that we work with on issues around cleanup. And it hurts me when we get just pieces -- bits and pieces and I see, you know, everybody is not getting the same thing. We're not all on the same level. That's the reason why I requested this, because I knew I was going to go out there and get a lesson one on -- lesson one-on-one on this and try to understand how it's done, but you told me that this breaks down the radiation at the last meeting. It's in the minutes.

DR. LUDWIG: Well, it depends on what you're talking about with respect to radiation. There are radionuclides that are ---

MS. BRADSHAW: You're talking about gamma and the cobalt that's in this water. We're not talking about other things.

DR. LUDWIG: Well, cobalt would be treated with ZVI. If you have radionuclides, if that's the form of radiation you're talking about, they will be treated with zero-valent iron.

MS. BRADSHAW: It won't make it go all the way. It said that this particular thing is used for solvents. Did I understand what you said about the ethylenes, that family? Yeah, it will break it down.

DR. LUDWIG: Oh, yes. The radionuclides aren't going to be broken down; right. They get absorbed by the ZVI. Yes, they get absorbed. They're not broken down.

MS. BRADSHAW: When you were talking about the half-life of the ethylene family, when you went to talk about the half-life of how to break it down -
-

DR. LUDWIG: Right.

MS. BRADSHAW: --- it just doesn't get rid of it.

DR. LUDWIG: Yes, it does.

MS. BRADSHAW: So, you're saying this is drinkable water?

DR. LUDWIG: I'm saying -- I'm telling you if you have groundwater that contains those contaminants that I talked about and you have a ZVI system that is thick enough, it will completely treat those contaminants so that the groundwater that's over on this side will be drinkable, yes, but ---

MS. BRADSHAW: So, you're saying that water will be clean enough to sink a well and start drinking it?

DR. LUDWIG: I'm just saying with respect to the contaminants that I'm talking about.

MS. BRADSHAW: That you're talking about. If there is anything else in there that it doesn't break down, it's not safe.

DR. LUDWIG: I'm not sufficiently familiar with your site to know whether there are any other contaminants.

MS. BRADSHAW: Will you please ---

MR. BALLARD: Those ---

MS. BRADSHAW: Will you please ---

MR. BALLARD: Those are -- those are organics ---

MS. BRADSHAW: That's not everything.

MR. BALLARD: Those are the contaminants which through the Risk Assessment process we determined were the contaminants that would cause unacceptable risks, and, therefore, those were the contaminants that we focused on for treating to bring the water back into, you know, acceptable quality.

MS. BRADSHAW: "Acceptable." Please use words that people can understand.

MR. BALLARD: Acceptable quality, drinking water quality.

MS. BRADSHAW: So, we can ship this water to Atlanta and EPA, and you will drink it. I just wanted to get my point across.

DR. LUDWIG: Thank you, yes.

MR. TYLER: On the chlorine atoms, it's kind of like a dishwasher deal that you've got going on here. You're going to mix all of this stuff up, absorb it in the ground, and it's going to be harmless, and it's going to stay there harmless.

DR. LUDWIG: When you're putting in -- what you're doing is you're putting it in the path of the groundwater that is moving -- that moves through it, and, so, as the groundwater with these contaminants moves through it, these reactions are going to take place, yes.

MR. TYLER: You are going to have some sludge that is essentially going to be harmless, stuff that you mixed up together?

DR. LUDWIG: Yes, it should be harmless. Because these contaminants are being broken down into totally harmless end products, like carbon dioxide, which you breathe in.

MR. TYLER: The process to break it down.

MR. BALLARD: I don't think -- if I understand your question correctly, it's not like we have a residual sludge, treatment sludge. It's that the contaminants pass through, strip off the chlorines. The chlorines pass out as chloride and the rest of the molecule gets broken down ultimately into carbon dioxide.

So, the only thing that occurs over time with the iron is the rusting process and through -- you know, the slide showing the different sections in the groundwater treatment process, you get some precipitation of calcium carbonates, iron carbonates on to the iron itself, but that's the only thing that stays in the treatment zone, would be those kinds of product, you know, precipitates. The rest of it, compounds that we're concerned with treating pass through, are treated as they pass through and emerge on the other side as nontoxic end products.

MR. TYLER: In other words, they're above EPA's acceptable values before they hit the barrier.

MR. BALLARD: Right.

MR. TYLER: After they leave the barrier, they are equal to EPA's acceptable barrier.

MR. BALLARD: Right. That's what I talked about the treatment zone.

MR. TYLER: Let's you know -- so, all right, it's bad on this side, good on this side.

MR. BALLARD: That's right.

MR. TYLER: And what's left is clean ---

DR. LUDWIG: Is rusted iron.

MR. TYLER: Left in the ground and the barrier will stay there.

DR. LUDWIG: Eventually it's going to form into iron oxides, which, again, is a mineral that's found in nature.

MR. TYLER: I noticed the arrow of the plume. Let me talk to you about which way these plumes are going and how they're going. Is it possible for that plume to burst or the water comes back in the opposite direction? Will that ---

DR. LUDWIG: As a result of the ZVI?

MR. TYLER: The direction of the plume.

MR. BALLARD: If the question is if it possible that -- we don't have a good handle on the direction of the flow of the groundwater and, therefore, the direction of the flow?

MR. TYLER: Right.

MR. BALLARD: I think your question will be answered if you could hold that one until Tom makes his presentation. Because -- but just to preface it, I would say that we think we do have a good handle on the groundwater flow and the plume boundaries out there at Dunn Field, considering how many wells we put in there just since June and how many we had before that.

MR. TYLER: Another point I would like to make, Ms. Bradshaw does have a valid point. This is a dump. So we really don't know what's there. We've just got the historical records where people were told what's down there. In fact, in the bad old days, they tell you to dump it or you won't keep your job. So, you know, they will tell you this is washing powder when you know common sense tells you washing powder don't look like this.

So, a lot of this stuff that we know is in the ground (unintelligible) barrier. However, if an unknown chemical comes through that barrier, we will presume that this is treatable or -- you know, the unknown fact. Because it's a dump. I don't care how you put it.

MR. BALLARD: Well, again, Dr. Ludwig really couldn't answer. It's a site specific question, and I guess the only way I could answer that is to say that during the investigation process, we did full scan sampling for all of the target compounds and target analytes on EPA's list of organic and inorganic contaminants. And over several rounds of sampling, we got a good understanding of the contaminants that are in the groundwater, and it was those contaminants in the groundwater which directed us toward using this technology.

Because we have several different contaminants, and maybe one treatment process would do one or do some contaminants but wouldn't get these others. So the reason we focused on zero-valent iron is because it had the broadest applicability. We haven't seen the inorganic contaminants that exceed the drinking water standards in the groundwater which would have caused us to select another technology.

MR. TYLER: It's the best on the market?

MR. BALLARD: Yes, sir.

MR. MORRISON: We need to have some clarity. This is Jim Morrison from Tennessee Department of Environment and Conservation. Ms. Bradshaw brought up an issue about radiation. This is the first it's ever been introduced. There is no evidence to suggest that radiation sources have ever been here. I just want to make certain everyone understands this has hit us out of left field. There is -- there is no substantiation of this, and I don't know where it came from.

So, I just want to make that clear, that that is not an issue at this facility. Radiation is not an issue at this facility.

DR. LUDWIG: Yes.

MS. HOOKS: I just want to make sure that I understand this correctly. During this process of the contaminants that you tested and based on EPA guidelines, this site has been tested for all of those things that EPA in any site of this type that may be something that we should be concerned about. So we looked at all of those. We have narrowed it down to out of a hundred let's just say to ten, and these are the ten they have found. And ZVI has been chosen as the technology that we can use in order to eradicate those ten targeted things that now we know are above a safety level. This will eradicate those and will return the groundwater to acceptable conditions from a community standpoint. Is that where we are?

MR. BALLARD: Yes, that's where we are.

MS. HOOKS: And the iron that is going to be left will only break down to a state that is found in nature anyway, and there will not have to be any remediation of that as a result of what is left. Is that correct?

MR. BALLARD: That's right.

MS. HOOKS: Am I on the same page?

DR. LUDWIG: Yes.

MS. HOOKS: Thank you.

MR. BALLARD: And actually as per your request a year ago, that got us to where we are tonight.

DR. LUDWIG: Any other questions?

MR. MYERS: Permeability versus time; how does that work?

DR. LUDWIG: That has been an issue, and I talked about the precipitates that form, and there have been, you know, these two full scale walls now that have been in place for -- one has been in place for ten years, one for nine. There has been no indication of any decreased permeability as a result of the precipitation. But there are precipitation reactions that occur, and that has been one of the issues, do these precipitation reactions potentially down the road impact the permeability of the ZVI system. And to date, there has been no evidence that that kind of thing occurs. However, if you have a very highly mineralized water, it certainly -- one would be more wary of that because you would expect a lot more precipitation to occur if you have a highly mineralized water entering your zero-valent iron system.

MR. BALLARD: Meaning hard water.

DR. LUDWIG: Hard water, yes. So, to date, given the systems that have been installed, there has been no evidence of any decreased permeability associated with the walls. Now, normally also when you design these systems, you design them to have a permeability significantly higher than your surrounding aquifer system, that's usually the objective, so that, you know, even if there was some kind of small decrease in permeability as a result of precipitation reactions, it wouldn't have any impact as long as your wall continues to have a permeability greater than the surrounding active material, you're in good shape. Your ZVI system is not going to continue to have a permeability greater than your surrounding aquifer system. But that's an issue that continues to be looked at. Because, again, as long as a full scale system has been in for ten years and there's no

evidence of any kind of affect like that, but they are going to continue to monitor that kind of thing. Any other questions?

MR. MYERS: You're also injecting sugar. What about microbial reactions down there or changes in the microbial ecosystem?

DR. LUDWIG: Yes, it's a carbon source. So, it's going to trigger some microbial activity. They're sugars. You know, it's a sugar material that's down there. So, there is no evidence to suggest that even if there was a build up in microbial activity that it's going to have a kind of adverse impact. There's -- are you thinking in terms of clogging things up or ---

MR. MYERS: You should get some iron producing bacteria, also.

DR. LUDWIG: Right, but, again, there has been no evidence to date with all the systems that have gone in that there is any kind of reduction in permeability even at the (unintelligible).

MR. BALLARD: It would deplete relatively quickly.

DR. LUDWIG: That's right. I mean, it's flowing -- it's going to be flowing away from the whole system and going downgradient. So it's not going to be sticking around. It's going to be breaking down and moving away.

PLANS FOR USE OF ZERO-VALENT IRON, DUNN FIELD

MR. HOLMES: My name is Tom Holmes with MACTEC Engineering and Consulting. We're the RA (Remedial Action) contractor, Remedial Action contractor for DDMT (Defense Depot Memphis, Tennessee). I'm just going to speak a few minutes about how we've used ZVI already and what our plans are for the future.

This is a map of Dunn Field and the surrounding area to the west. Here is Dunn Field here. (Indicating) Here is the MLGW substation. Here are the railroad tracks. This is the -- this outline

here, the green line, is a combination of the hundred parts per billion contour for some of the major contaminants we have over there: TCE, perchloroethane and dichloroethene. It's not all the contaminants. There's some lower -- some carbon tetrachloride, chloroform down here that doesn't show up, but far and away the highest concentrations are in this central area.

There are three basic uses or three basic areas of ZVI use. The first one we have completed. In October we spoke about it and did the work. We did the work in November and December at this early implementation, which is south of Menager by the MLGW substation.

We currently are -- CH2M Hill is preparing a Remedial Design for the on-Depot part of Dunn Field for the groundwater cleanup. That's going to include ZVI injections in here, in these four areas, to treat the most contaminated areas out to a fairly low level. (Indicating) The bounds were set based on the contamination that is there, and it's going to treat out to a fairly low level of contamination.

Both of these, the early implementation and the source area work, was ZVI injections, and the permeable reactive barrier is being planned. Right now the current plan, the initial plan, was that it would be on the far side of the railroad tracks. We are now -- I'll show you some other information about water levels and thickness of aquifers. We're just getting underway with Remedial Design for the off-Depot groundwater remediation, and we're looking at where the best place, the most effective place to put the PRB and possibly some additional ZVI injections in the area between here and here (Indicating).

I'm going to show you two over here. I mentioned about the number of groundwater wells we have put in recently. All these that you see in red here all have been installed -- probably 30 something wells installed since June. We've been sending out fact sheets about that, and y'all might have seen all the activity over here, and they have a good handle on the extent of the contamination of these solvents and of the groundwater flow.

I don't have a chart of that. I've got these two cross-sections I'm going to show you in a minute. This is the groundwater flow map showing groundwater flow. This is Dunn Field here. Here are all the new wells I just pointed out. This is showing the groundwater flow coming this way, to here (Indicating). And it's sort of a trough, and it goes up to the north here, but the extent of contamination is about right out to about here or where you see the line there, (Indicating). And I will be happy to look at that after this with anybody if you have any questions on that.

I'm going to show you two cross-sections now. One of them is a north/south one. It goes -- this point here, MW67, one of the older wells and deeper wells up to the north to where we just put some in here on the other side of Person and Ragan. Then the next cross-section will be from Dunn Field going this way (Indicating).

The main reason I wanted to show this -- these show the different layers. This is the fluvial aquifer. We've got the loess, the silty clay, silk up in here, this brown, red. Then we've got the fluvial, primarily sand and gravel is in here, the yellow. This blue line here is the water table, basically, connecting the water levels that

we found in all these different wells, drops off down here.
(Indicating)

This gray is a thick type clay. All the new wells is -- the clay is important because it bounds the bottom of the aquifer, and it's a tight clay, and so it's called an aquaclude, and there's not really any significant flow that's going to go down through there. It forms a barrier to the flow as long as it's present. Just about all the wells we're putting in now --we want to confirm this clay. We're drilling down 10 to 20 feet into it, make sure we're not just hitting a couple inches of it and stopping. We're making sure it's there. So that's why you see this sort of thick, gray here. (Indicating)

MW67 is one of the first wells. It's been around for a long time, and that's what you want in the field. One of these -- it's the only well on the Depot that monitors the Memphis Sand (Aquifer). So, you can see that here is the Memphis Sand down here. It's at a depth -- it's at an elevation of about 30 feet above sea level. Ground surface is about 270 to 280 feet.

We get into this clay in this well at about 180 feet, and then you have about -- it's like from 220 to almost 100 feet of clay here. Then we get into a little sand. This is what we call the intermediate aquifer, and then it goes through another 70 feet of clay before it gets down to the Memphis Sand. So this is where the drinking water for Memphis is coming from.

In this instance, there is a lot of clay in between the fluvial aquifer in here, (Indicating) and then you can see the water level and the saturated thickness, the amount of water in the fluvial aquifer there

is maybe 7 or 8 feet here, up to as much as 50 feet there.

Here is, as I said, a cross-section going from Dunn Field. MW73 on Dunn Field is where the treatability study was done back in 2003 for ZVI, going across -- the railroad tracks are about here. MW165 was shown on the other map, too. That's at Ragan. This is where the treatability study was in here, between 150 and 158. This is at a slightly different scale. Again, you can see the water level here. Here is the clay that we saw in these borings. You can see right here the water is only about three or four feet thick -- deep in the fluvial aquifer there. (Indicating) The initial plan for the permeable reactive barrier and it's still under consideration, was about here, where the water is maybe up to 18 -- 15 to 18 feet thick. Over here it's about 3 to 4 feet thick. I'm thinking that it may be more effective and can do a better job to put the PRB here and then do some ZVI in there, additional ZVI injection, to hit the groundwater contamination that's downgradient of the wall. (Indicating)

So this is where we're talking here. This is where the wall is now. This is where that thin area of water is. (Indicating) If we put the permeable reactive barrier here, it's going to clean anything that's going through it as it moves off the site. Of course, we're also treating on the site. So we've wiped that out, and then we would put maybe some ZVI downgradient, up here, so we would take care of this part of the plume that's down there. And this -- as I said, this is still in the Remedial Design process.

This is just a blowup of the early implementation area. Here is Menager. This is the substation here. (Indicating) We drilled 14 borings. I guess one thing to point out, what we're doing with

these borings, we drill them down to the clay and then inject the iron in two-foot stages, come up until we get to the groundwater level. We're not -- you know, we're not filling the whole thing up with iron. The iron is all going into the soils down here in the aquifer, about 70 to 80 feet below the ground surface.

But, anyway, this is -- the 14 locations are in blue where the injections were. You can see the monitoring wells around it. The red ones, as I said, are the news ones. We had one that was here a long time ago that sort of led to this additional off-site work and all these others. So we've got a good monitoring network around the ZVI.

This was the work that was done. It started right before Thanksgiving and ended right after the first of the year. We've just collected the first samples for the analysis, and the analysis looks like its working well, as it did on the treatability study.

This is just a schematic of the ZVI injections. The first thing that we do is drill a hole just like we're drilling a boring for a monitoring well. Then we -- piping down there carries the gas down there. It's got these two packers that seal off the formation. The iron -- it starts off and injects nitrogen into the aquifer to fluidize, to get the sand, grains and gravel moving around. Then the water and the ZVI slurry is injected and then goes in place outside -- in here, in the formation. It will go out as far as the nitrogen gas can carry it, and it gets blocked by all the grains, sands out there and doesn't go any further, and then it is pretty much locked in place.

This just shows how it works. This is a little animation, and as I showed you, there are the packers, and you will see how -- this is sort of an animated version of how it works. So the hole is drilled. The injection equipment is in. The gas goes in. The gas stirs around all the soil particles, and then the nitrogen is introduced and blown out into it. We're trying to put about 0.5 percent of the weight of the soil is the amount of iron that we're aiming for in the injections. We calculated the amount of iron based on the amount of contamination, how long we want it to last and what we think it will take to clean up the solvents completely. And that is it. Do you have any questions? I will be happy to try and answer them.

MR. TYLER: What you said about where you're going to put a depth of, like, 4 feet and 18 feet. What determines where you're going to put them?

MR. HOLMES: We drill down until we hit the clay, that gray clay -- tight clay, and then -- and we've got monitoring wells around there that tell us where the water level is, and so we treat that area from the top of the clay to the top of the water.

MR. BALLARD: I think he was talking about once it's determined whether we put the PRB here or here. (Indicating)

MR. HOLMES: Okay, it's just where it would be most cost effective, but still the goal is -- the Remedial Action objective in the ROD (Record of Decision) is to clean up the groundwater to drinking water standards. So that doesn't change regardless of where we put the PRB or the ZVI. It's where it looks like it would be most effective both in time and cost to reach that objective.

MR. TYLER: Based on your experience, would you say that the deeper you put it, you would catch more than just a (unintelligible) or would the more shallow you put it or does the data determine that?

MR. HOLMES: Well, I mean, we've got all these wells that you saw out there, and we've got some where the water is thicker, we might have two wells there. If one has got say -- the water is 40 feet deep, 30 feet

deep. We might have one well 10 or 15 feet of screen that we're sampling the other part of the water, and then right beside it 5 to 10 feet away we'll have a well sampling the lower part. In some areas there's a difference between the amount of contamination from one to the amount of compounds that are in the other. It's the same compounds but at different concentrations, higher in the water table or lower.

So we'll look at that, and in most cases we're finding about the same level of contamination throughout that entire thickness of water. It's not like there's so much in it it's sinking down to the bottom, like forming another layer.

And, so, we are treating that whole area where we're finding the solvent at the concentrations that warrant treatment based on the Record of Decision.

MR. BALLARD: Did that answer your question?

MR. TYLER: Mercury is heavier than water. If you try to treat it at the top, you're not doing anything, but you look good.

MR. HOLMES: Right, but that's not -- one thing that has been discussed at a couple of meetings, some of, just a little bit off, but we have put together, just as a notice for the public, of the selected remedies that were in the ROD and the Record of Decision, both for the Main Installation and Dunn Field and the compounds, the chemicals, the metals in the soil, the solvents in the groundwater that were selected in the Record Of Decision for treatment. So this is what we're -- those are the things that we're trying to get based on the Record of Decision. And those are back there on the table, Alma.

MR. MORRISON: Jim Morrison from TDEC (Tennessee Department of Environment and Conservation) again. I just wanted to make a point of clarification on something Ms. Bradshaw said. In theory, when the

PRB is placed right there and this is downgradient from all contamination, what comes through the PRB would be a drinkable, potable water if the system is designed sufficiently. (Indicating)

However, here at the Depot we're putting in a PRB where we already have contamination downgradient of where the PRB is, but you've got to remember, this is a multiprong attack on this groundwater. We're taking care of the residual contamination in the unsaturated zone through soil vapor extraction. We're treating these additional hot spots both upgradient and downgradient of the PRB with the zero-valent iron to knock that contamination that's there out. The part where it's going to reach MCLs (maximum contaminant levels) are our point of compliance. If everything has been designed and we're constantly going back and looking at it and making certain that we're doing everything correctly, the point of compliance wells will be the point at which we've reached MCLs. That's where you get potable water for drinking right there.

So that was the one thing that really needed to be clarified. You can't put -- at least here at the Depot; you can't put a well on the other side of a PRB and have drinkable water. You've got to remember, it's a multifaceted approach to getting rid of the contamination right here, but where it will be potable is at the points of compliance, and, Turpin, you want to step in on that right there?

MR. BALLARD: No, that's good.

MR. MORRISON: Okay.

MR. HOLMES: I guess, Mike.

MR. DOBBS: If there are no more questions, this will conclude this evening's presentation on ZVI. However, Tom and the EPA rep and others

will stick around if anyone has any one-on-one questions or comments for you. I thank you for coming out tonight.

(Whereupon, at approximately 7:30 p.m. the Community Information Session was adjourned.)

Attendance List

Ms. Calondra Tibbs	Memphis/Shelby County Health Department
Ms. Brenda Digger	Memphis/Shelby County Health Department
Ms. Johnnie Mae Peters	RAB Member
Ms. Peggy Brooks	RAB Member
Mr. Mondell Williams	RAB Member/Co-Chair
Mr. Stanley Tyler	RAB Member
Ms. Doris Bradshaw	RAB Member/DDMT-CCC
Ms. Janet Hooks	RAB Member/Memphis City Council
Mr. P. Sidney	Citizen
Mr. Daniel Conti	Citizen
Ms. Jackie Noble	DLA
Mr. Mike Dobbs	DLA
Mr. Ralph Ludwig	EPA
Mr. Turpin Ballard	EPA
Mr. Evan Spann	TDEC
Mr. David Nelson	CHM2Hill
Ms. Denise Cooper	MACTEC
Mr. Tom Holmes	MACTEC
Mr. Steven Youngs	MACTEC
Ms. Keren Adderley	Frontline
Ms. Alma Moore	Frontline